Name________________________

Henry's Law Worksheet

Apply Henry's Law to solve the following problems.
You may use the following formula:

$$\frac{S_1}{P_1} = \frac{S_2}{P_2}$$

S_1 is the solubility of gas at pressure P_1
S_2 is the solubility of gas at pressure P_2

(1) If 0.24 g of a gas dissolves in 1.0L of water at 1.5 atm of pressure, how much of the gas will dissolve if the pressure is raised to 6.0 atm? Assume the temperature is held constant.

$\frac{S_1}{P_1} = \frac{S_2}{P_2}$ $S_2 = \frac{S_1 P_2}{P_1}$ $\frac{0.24g}{L}\left(\frac{6.0\ atm}{1.5\ atm}\right) = 0.96\ g/L$

(2) A gas has a solubility of 0.086 g/L at a pressure of 3.5 atm. At what pressure would its solubility be 2.3 g/L?

$\frac{S_1}{P_1} = \frac{S_2}{P_2}$ $P_2 = \frac{S_2 P_1}{S_1}$ $\frac{(2.3g)(3.5\ atm)}{(0.086g)} =$ ~~93~~ $94\ atm$

(3) The solubility of a gas changes from 0.95 g/L to 0.72 g/L. If the initial pressure was 2.8 atm, what is the final pressure?

$P_2 = \frac{S_2 P_1}{S_1}$ $\left(\frac{0.72g}{L}\right)\left(\frac{2.8\ atm}{1}\right)\left(\frac{L}{0.95g}\right) = 2.1\ atm$

Name ______________________________ Period ________

MOLARITY WORKSHEET #2: THE DILUTION EQUATION

Chemical reagents are often sold in *concentrated* form (high molarity) and then diluted for laboratory use. Let's say that a laboratory experiment requires 500 mL of 0.5 M HCl, but the stockroom contains only concentrated, 12 M HCl. How would you dilute the concentrated HCl?

The simplest way to solve this problem is to use the **dilution equation**, which is commonly written as: $\mathbf{C_1V_1 = C_2V_2}$, where C stands for "concentration" and V stands for "volume." This means that the initial concentration of a solution times its volume is equal to the new concentration times a new volume.

Remember that **diluting** a solution does not change the number of moles of solute; it only changes the amount of solvent. Therefore the number of moles of solute must remain the same. (This is the basis for the dilution equation).

Example (from above):
A laboratory experiment requires 500 mL of 0.5 M HCl but the stockroom contains only concentrated, 12 M HCl. How would you make up the dilute solution?

Identify variables:
C_1 = initial concentration of concentrated HCl, which is 12 moles/Liter.
V_1 = volume of concentrated HCl required to make the dilute solution **(your unknown!)**
C_2 = the desired concentration of dilute HCl, which is 0.5 moles/Liter.
V_2 = the desired volume of dilute HCl, which is 500 mL (or 0.5 L).

Solve for V_1:

$$V_1 = \frac{C_2V_2}{C_1} = \frac{(0.5\,\frac{mol}{L})(500\text{ mL})}{(12\,\frac{mol}{L})} = \mathbf{20.83\ mL}$$

So, in order to make the dilute solution, you must start with 20.83 mL of concentrated acid and add enough water to bring the final volume up to 500 mL.

Use the dilution equation to answer the following:

1. A solution of sodium hydroxide (NaOH), a strong base, has a concentration of 6.0 M. What volume of this solution must be used to make 1.0 liters of a 3.0 M solution of sodium hydroxide?

$M_1V_1 = M_2V_2$ $V_1 = \frac{M_2V_2}{M_1}$ ~~$\frac{(3.0)(1.0)}{6.0}$~~ = $\frac{(3.0M)(1.0L)}{(6.0M)} = 0.5L$

2. Concentrated sulfuric acid (H_2SO_4) has a concentration of 18.0 M. What volume of concentrated H_2SO_4 is needed to make 2.5 liters of a 1.0 M solution?

$M_1V_1 = M_2V_2$ $V_1 = \frac{M_2V_2}{M_1}$

$\frac{(2.5L)(1.0M)}{(18M)} = 0.14L$ or $140 mL$

3. 500 mL of water is added to 25 mL of 6.0 M hydrochloric acid. What is the final concentration of this solution in mol/L?

$M_1V_1 = M_2V_2$ $M_2 = \frac{M_1V_1}{V_2}$ $\frac{(6.0M)(25mL)}{(525mL)} = 0.29M$

4. 100 grams of solid sodium hydroxide (NaOH) are dissolved in 1.55 L of water.

a. Calculate the molarity of this solution.

$100g\ NaOH\left(\frac{1 mol\ NaOH}{40g}\right)\left(\frac{1}{1.55L}\right) = 1.61\ M$

b. If the solution is diluted to a volume of 2.75 L, determine its molarity.

~~$\frac{1.61 mole}{1L} = \frac{X}{2.75L}$~~

$M_1V_1 = M_2V_2.$

$M_2 = \frac{M_1V_1}{V_2}$ $\frac{(1.61M)(1.55L)}{(2.75L)} = 0.907M$

Answers: 1) 500 mL 2) 138.8 mL 3) 0.29 mol/L 4a) 1.61 mol/L 4b) 0.91 mol/L

2. Concentrated sulfuric acid (H_2SO_4) has a concentration of 18.0 M. What volume of concentrated H_2SO_4 is needed to make 2.5 liters of a 1.0 M solution?

$M_1V_1 = M_2V_2$ $V_1 = \frac{M_2V_2}{M_1}$

$\frac{(2.5L)(1.0M)}{(18M)} = 0.14L$ or $140 mL$

3. 500 mL of water is added to 25 mL of 6.0 M hydrochloric acid. What is the final concentration of this solution in mol/L?

$M_1V_1 = M_2V_2$ $M_2 = \frac{M_1V_1}{V_2}$ $\frac{(6.0M)(25mL)}{(525 mL)} = 0.29M$

4. 100 grams of solid sodium hydroxide (NaOH) are dissolved in 1.55 L of water.

   a. Calculate the molarity of this solution.

   $100g\ NaOH \left(\frac{1 mol NaOH}{40g}\right)\left(\frac{1}{1.55L}\right) = 1.61 M$

   b. If the solution is diluted to a volume of 2.75 L, determine its molarity.

   ~~$\frac{1.61 mole}{1L} = \frac{x}{2.75L}$~~

   $M_1V_1 = M_2V_2$.

   $M_2 = \frac{M_1V_1}{V_2}$ $\frac{(1.61M)(1.55L)}{(2.75L)} = 0.907M$

Answers: 1) 500 mL 2) 138.8 mL 3) 0.29 mol/L 4a) 1.61 mol/L 4b) 0.91 mol/L

Solutions Worksheet #5

1. What would be the percent concentration of each of the following solutions?

   a. 54.0 g of $AgNO_3$ g is dissolved in 128 g of water. (54/182) x 100 = 29.7 %

   b. 4.22 g of K_2CO_3 is dissolved in 426 mL of water. (4.22g/430.22g) x 100 = 0.981 %

   c. 0.762 g of ZnF_2 is dissolved in 1.30 liters of water. (0.762g/1300g) x 100 = 0.0586 %

g of solute / g solution — solute + solvent g

2. What weight of solute is needed to produce each of the indicated solutions? Yeah!! Proportions

   a. 500.0 g of a 6.40% NaCl solution. $\frac{6.40}{100} = \frac{x}{500}$ x = 32.0g NaCl

   b. 136 g of a 14.2% $LiNO_3$ solution. $\frac{14.2}{100} = \frac{x}{136}$ x = 19.3g $LiNO_3$

   c. 42.2 g of a 7.60% $AgNO_3$ solution. $\frac{7.60}{100.0g} = \frac{x}{42.2g}$ x = 3.21g $AgNO_3$

3. How many grams of water should be used in each of the problems in "2" above.

   a) 500 − 32 = 468g H_2O b) 136 − 19.3 = 116.7g H_2O c) 42.2 − 3.21g = 38.99g H_2O

4. How many grams of the following solutes would you need to prepare the indicated volume and concentration of the solutions given?

   a. 340. mL of a 1.82 M aluminum nitrate solution. $\frac{1.82\ mol}{1L}\left(\frac{213g}{1mol}\right)\left(\frac{1L}{1000mL}\right)\left(\frac{340.mL}{1}\right)$ = 132g $Al(NO_3)_3$

   b. 25.0 mL of a 4.26 M potassium cyanide solution. $\frac{4.26mol}{1L}\left(\frac{65.1g}{1mol}\right)\left(\frac{1L}{1000mL}\right)\left(\frac{25.0mL}{1}\right)$ = 6.93 KCN

   c. 370. mL of a 0.00674 M ammonium sulfate solution. $\frac{0.00674mol}{1L}\left(\frac{132.1g}{1mol}\right)\left(\frac{1L}{1000mL}\right)\left(\frac{370.mL}{1}\right)$ = 0.329g $(NH_4)_2SO_4$

5. What should the final volume(mL) of each solution be so that the amount of solute dissolved will produce the indicated concentration.

   a. 2.86 g of copper(I) carbonate to produce a 0.640 M solution. 2.86g $\left(\frac{1\ mol}{187.2g}\right)\left(\frac{1L}{0.640mol}\right)$ = 0.02L or 20mL

   b. 12.62 g of calcium hydrogen carbonate to produce a 1.28 M solution. 12.62g $\left(\frac{1mol}{101.1g}\right)\left(\frac{1L}{1.28mol}\right)$ = 0.0975 or 97.5

   c. 54.26 g of sodium oxide to produce a 0.430 M solution. Na_2O = 46 + 16 = 62 54.26g $\left(\frac{1}{62}\right)\left(\frac{1}{0.43}\right)$ = 2.19 L

187.2 = Cu_2CO_3
101.1 $CaHCO_3$

6. What will be the final concentration of a solution prepared by dissolving the indicated solute in enough water to produce the indicated volume of solution?

   a. 15.4 g of strontium acetate filled up to 340. mL. 15.4g $\left(\frac{1mol}{205.6}\right)\left(\frac{1}{0.340L}\right)$ = 0.220M $Sr(C_2H_3O_2)_2$

   b. 176.2 g of Iron(III) sulfite filled up to 1.42 liters. 176.2 $\left(\frac{1mol}{400.1}\right)\left(\frac{1}{1.42L}\right)$ = 0.310M $Fe_2(SO_3)_3$

   c. 3.22 g of copper(I) chlorate filled up to 40.0 liters. 3.22g $\left(\frac{1mol}{147.1}\right)\left(\frac{1}{40.0L}\right)$ = 5.47×10^{-4} M $CuClO_3$

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7. What will be the final concentration of the solution indicated that will result from the following dilutions?

$M_2 = \frac{M_1V_1}{V_2}$

a. 14.0 mL of a 4.20 M Na_2CO_3 solution is diluted to 86.0 mL. $\frac{(14.0)(4.20)}{86.0}$ 0.684M

b. 450. mL of a 1.22 M HCl solution is diluted to 1.26 liters.

$\frac{(0.450L)(1.22)}{1.26} = 0.436$ M

8. To what volume should the indicated solution be diluted to produce a solution of the desired concentration?

$V_2 = \frac{M_1V_1}{M_2}$

a. 12.0 mL of a 0.64 M KCl solution to produce a 0.19 M solution. $\frac{12.0 mL \; 0.64 M}{0.19 M} = 40$ mL

b. 84.2 mL of a 4.60 M $KMnO_4$ solution to produce a 1.42 M solution. $\frac{(84.2)(4.60)}{1.42} = 273$ mL

9. What volume of the indicated solution is needed to produce the volume and concentration of a diluted solution as indicated?

$V_1 = \frac{M_2V_2}{M_1}$

a. 2.73 M NaOH solution to prepare 142 mL of a 0.540 M solution. $\frac{(142)(0.54)}{2.73} = 28$ mL

b. 0.0076 M SnF_2 solution to prepare 25.0 mL of a 0.00027 M solution. $\frac{(25)(0.00027)}{0.0076} = 0.89$ mL

1 lb. = 454 g 1 qt. = 946 mL 4 quarts = 1 gallon density of water = 1g/mL

Solutions

1.
a. 29.7%
b. 0.981%
c. 0.0586%

2.
a. 32.0 g NaCl
b. 19.3 g $LiNO_3$
c. 3.21 g $AgNO_3$

3.
a. 468 g H_2O
b. 117 g H_2O

4.
a. 132 g $Al(NO_3)_3$
b. 6.93 g KCN
c. 39.0 g H_2O
c. 0.329 g $(NH_4)_2SO_4$

5.
a. 23.9 mL
b. 60.8 mL
c. 2,040 mL

6.
a. 0.220 M
b. 0.353 M
c. 5.48 x 10^{-4} M

$volume_A(L) \times molarity_A \times mole\ ratio\left(\frac{B}{A}\right) \times \frac{1}{volume_B(L)} = $ Molarity of B.

Worksheet - Titration Problems

1. What is the M of NaOH if it takes 40 ml of NaOH to reach the equivalence point in a titration with 50 ml of 0.2 M HCl? (0.25M) $NaOH + HCl \rightarrow H_2O + NaCl$

   ? M, 40 mL | 0.2 M, 50 mL

   $0.05L\left(\frac{0.2mol}{1L}\right)\left(\frac{1mol}{1mol}\right)\left(\frac{1}{0.04L}\right) = 0.25M$ NaOH

2. 50 ml of 0.3 M KOH are required to titrate 60 ml of H_2SO_4. What is the M of the H_2SO_4? (0.125M)

   $2KOH + H_2SO_4 \rightarrow K_2SO_4 + 2H_2O$

   $0.05L\left(\frac{0.3mol}{L}\right)\left(\frac{1mol\ H_2SO_4}{2mol\ KOH}\right)\left(\frac{1}{0.06L}\right) = 0.125M$

3. 60 ml of 1.2 M NaOH are required to titrate 40 ml of HF. What is the M of the HF? (1.8M)

   $0.06L\left(\frac{1.2mol}{1L}\right)\left(\frac{1mol}{1mol}\right)\left(\frac{1}{0.04L}\right) = 1.8M$

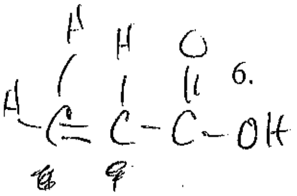
4. What volume of 0.40 M NaOH would be required to titrate 100 ml of 0.25 M HCl? (62.5mL)

   $0.100L\left(\frac{0.25mol}{1L}\right)\left(\frac{1mol\ NaOH}{1mol\ HCl}\right)\left(\frac{1L}{0.4M}\right) = 62.5L$

5. 40 ml of 0.1M H_3PO_4 are required to titrate 150 ml of NaOH to the equivalence point. What is the M of the NaOH? (0.08M)

   $H_3PO_4 + 3NaOH \rightarrow Na_3PO_4 + 3H_2O$ (A, B)

   $0.04L\left(\frac{0.1mol_A}{L}\right)\left(\frac{3mol\ NaOH}{1mol\ H_3PO_4}\right)\left(\frac{1}{0.15L}\right) = 0.08M$ NaOH



6. 55 ml of 1.2 M H $C_2H_3CO_2$ are used to titrate a sample of 0.67 M $Ba(OH)_2$. What is volume of the $Ba(OH)_2$ used? (49.3mL)

   $Ba(OH)_2 + 2HC_2H_3O_2 \rightarrow Ba(C_2H_3CO_2)_2 + 2H_2O$

   $0.055L\left(\frac{1.2mol}{L}\right)\left(\frac{1}{2}\right)\left(\frac{1}{0.67}\right) = 0.049L$ or 49 mL $Ba(OH)_2$

7. 90 ml of 0.25 M $Ca(OH)_2$ are required to titrate 100 ml of HCl. What is M of the HCl? (0.45M)

   $Ca(OH)_2 + 2HCl \rightarrow CaCl_2 + 2H_2O$

   $0.09L\left(\frac{0.25mol}{1L}\right)\left(\frac{2mol\ HCl}{1mol}\right)\left(\frac{1}{0.1L}\right) = 0.45M$

8. 50 ml of 0.45M $Sr(OH)_2$ are required to titrate a .75 M H_2SO_4 sample. What is the volume of the H_2SO_4? (30mL) $Sr(OH)_2 + H_2SO_4 \rightarrow SrSO_4 + H_2O$

   $0.05L\left(\frac{0.45mol}{1L}\right)\left(\frac{1mol\ H_2SO_4}{1mol\ Sr(OH)_2}\right)\left(\frac{L}{0.75mol}\right) = 30mL$ or $0.03L$

9. Would it take more 0.1 M HCl or 0.1 M H_2SO_4 to neutralize 30 ml of NaOH?

   HCl

   A $HCl + NaOH \rightarrow H_2O + NaCl$

   B $H_2SO_4 + 2NaOH \rightarrow 2H_2O + Na_2SO_4$

   $\frac{XM\ NaOH}{L}\left(0.03L\right)\left(\frac{1}{1}\ \frac{1}{2}\right)\left(\frac{L}{0.1mol}\right)$

10. 30 ml of 0.3 M NaOH are required to titrate H_3PO_4 to the equivalence point. How many moles of H_3PO_4 are needed to reach the equivalence point? (0.03 mols)

    $3NaOH + H_3PO_4 \rightarrow Na_3PO_4 + 3H_2O$

    $0.030L\left(\frac{0.3mol}{1L}\right)\left(\frac{1mol}{3mol}\right)$ = 0.003 mol.

Name ______________________ Date ________________ Class ________________

19 ACIDS, BASES, AND SALTS

Practice Problems

In your notebook, solve the following problems.

SECTION 19.1 ACID–BASE THEORIES

1. Identify the hydrogen ion donor(s) and hydrogen ion acceptor(s) for ionization of H_2SO_4 in water. Label the conjugate acid–base pairs.
2. Identify all of the ions that may be formed when H_3PO_4 ionizes in water. H^+ PO_4^{3-} H_3O^+
3. Classify the following acids as monoprotic, diprotic, or triprotic.
   a. HCOOH mono   b. HBr mono   c. H_2SO_3 di   d. H_3ClO_4 tri
4. What would you expect to happen when lithium metal is added to water? Show the chemical reaction. $2Li_{(s)} + 2H_2O_{(l)} \rightarrow 2LiOH_{(aq)} + H_{2(g)}$
5. In the following chemical reaction, identify the Lewis acid and base.

$$BF_3 + F^- \rightleftharpoons BF_4^-$$

6. Describe some distinctive properties of acids. Sour,
7. Describe some distinctive properties of bases. bitter,

SECTION 19.2 HYDROGEN IONS AND ACIDITY

1. A solution has a hydrogen ion concentration of $1 \times 10^{-6}M$. What is its pH? 6
2. What is the pH of a solution if the $[H^+] = 7.2 \times 10^{-9}M$? 8.1
3. What is the pOH of a solution if the $[OH^-] = 3.5 \times 10^{-2}M$? 1.5
4. What is the pOH of a solution that has a pH of 3.4? 10.6
5. Classify each solution as acidic, basic, or neutral.
   a. $[H^+] = 2.5 \times 10^{-9}M$ basic
   b. pOH = 12.0 acidic
   c. $[OH^-] = 9.8 \times 10^{-11}M$ acidic
   d. $[H^+] = 1 \times 10^{-7}M$ neutral.
   e. pH = 0.8 acidic
6. Calculate the pH of each solution.
   a. $[H^+] = 1 \times 10^{-5}M$ 5
   b. $[H^+] = 4.4 \times 10^{-11}M$ 10.4 = 10. SF
   c. $[OH^-] = 2.2 \times 10^{-7}M$ 14-6.7 = 7.3
   d. pOH = 1.4 12.6
7. Classify the solutions in problem 6 as acidic or basic. a) acidic b) basic c) basic d) basic
8. Why is there a minus sign in the definition of pH? because there is no negative pH
9. A solution has a pOH of 12.4. What is the pH of this solution? 1.6
10. What is the pH of a solution with $[H^+] = 1 \times 10^{-3}M$? 3